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VISION-BASED NAVIGATION SYSTEM FOR COST-EFFICIENT MITIGATION MISSIONS

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ABSTRACT

Robotic exploration missions to small bodies require advanced technologies. Advances in the last years can be applied in order to obtain more and better scientific data and at the same time to keep cost down. Proximity phases are the most demanding mission phases. In these phases science is carried out, there are intense operations and collision risk is a major concern.

In addition to improved fast operations, derived from ROSETTA experience, the Guidance, Navigation & Control (GNC) system enables more efficient operations in the vicinity of the asteroid. This is particularly true for missions to binary asteroids in which robustness is fundamental because of the highly uncertain environment. Considering reduced cost and robust technology available in Europe, a vision-based GNC system has been developed by GMV under a series of ESA contracts.

The GNC system in combination with the ground operations cover the proximity phases of missions like Marco Polo-R and AIM. Ground involvement is of great importance to reduce the on-board autonomy while maintaining simple, low-frequency ground control. The main benefit is not only cost reduction but also increased scientific data return (longer observation slots) and of higher quality.

Using different image processing techniques and reduced a priori knowledge safe close approach and station keeping can be performed while properly pointing the science instruments towards the asteroid. Once the navigation cameras can achieve higher surface resolution, more complex image processing techniques can be used to increase the performance. The higher reactivity and accuracy permit flying

trajectories closer to the surface and with better pointing accuracy. The increased accuracy can also be used to help guiding a kinetic impactor or to deliver a lander in a small asteroid (e.g. Didymos secondary).

Extensive testing in a high-fidelity, closed-loop simulator with realistic images has validated the complete system to TRL-4. Real-Time tests are executed with the flight-representative avionics for the vision-based navigation chain and the rest of the GNC. Then, the autonomous vision-based GNC avionics is tested in GMV's optical laboratory. A camera provides the images representative of the navigation camera. The camera is stimulated in closed-loop in order to produce images as close as possible to flight images. Finally, dynamics tests of the avionics are performed with camera stimulated with a scaled asteroid 3D model in a representative environment. GMV's robotic facility (platform-art©) is used to simulate the dynamic and kinematic conditions. The facility synchronizes the relative motion of the SC, asteroid and Sun. After this V&V process the autonomous vision-based GNC system is at TRL 5-6.

During these validation steps, the GNC system is refined and recommendations at mission and system level are derived.

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